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REPORT

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SHOULDER INVESTIGATION

***

NEW YORK STATE THRUWAY

SOUTHBOUND LANE

MILEPOSTS 135 TO 140

STATE OF NEW YORK
DEPARTMENT OF PUBLIC WORKS
BUREAU OF SOIL MECHANICS

APRIL, 1958

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WM. P. HOFMANN
DIRECTOR

STATE OF NEW YORK
DEPARTMENT OF PUBLIC WORKS

JOHN W. JOHNSON
SUPERINTENDENT

ALBANY 1, N.Y.

April 10, 1958

Subject: Transmittal of Report
"Shoulder Investigation
New York State Thruway
Mileposts 135 to 140"

Mr. C. H. Lang, Chief Engineer
New York State Thruway Authority
Box 189
Albany, New York

Dear Sir:

In accordance with your request of July 12, 1957 to Mr. T. F. FitzGerald, Chief Engineer, Department of Public Works, this Bureau has performed and completed an investigation and analysis of the materials composing the southbound shoulder of the Thruway between Mileposts 135 and 140.

The results of this investigation constitute the contents of the above report, transmitted herewith.

Very truly yours,

Wm. P. Hofmann

Wm. P. Hofmann
Principal Soils Engineer

WPH:GBM
Enclosure
cc: Mr. T. F. FitzGerald (1)
Mr. G. W. McAlpin (1)

WM. P. HOFMANN
DIRECTOR

BUREAU OF SOIL
MECHANICS

STATE OF NEW YORK
DEPARTMENT OF PUBLIC WORKS

JOHN W. JOHNSON
SUPERINTENDENT

ALBANY 1, N.Y.

April 19, 1938

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New York State Thruway Authority
Box 189
Albany, New York

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REPORT

SHOULDER INVESTIGATION

NEW YORK STATE THRUWAY
SOUTHBOUND LANE
MILEPOSTS 135 TO 140

State of New York
Department of Public Works
Bureau of Soil Mechanics

April 1958

REPORT

SHOULDER INVESTIGATION

NEW YORK STATE THRUWAY
SOUTHBOUND LANE
MILEPOSTS 135 TO 140

State of New York
Department of Public Works
Bureau of Soil Mechanics

April 1952

1. PURPOSE

The work described herein comprises a continuation of the cooperative investigation concerning the general performance of the mechanically stabilized shoulders along the New York State Thruway by the Thruway Authority and the Bureau of Soil Mechanics of the Department of Public Works. The results of previous work by the Bureau were presented in a report, "New York State Thruway, New York City to Schenectady, Investigation of Performance of Shoulders", dated November 1956.

The following report concerns only that section of the Thruway between M.P. 135 and M.P. 140. The purposes of this particular report are as follows:

(A) To investigate and describe in detail by laboratory tests, the materials constituting the existing southbound outside shoulders between the above mileposts.

(B) To present recommendations describing the requirements for optimum shoulder materials.

(C) To present recommendations describing basic shoulder maintenance considerations and procedures.

(D) Using the data in (A), (B) and (C), to arrange, if feasible, a test section and a control section between the above mileposts, and maintaining accurate cost records on these sections in order to indicate:

(a) Suitable and economical methods and procedures for maintaining properly constructed shoulders.

1. [illegible]

The work described herein comprises a continuation of the cooperative investigation concerning the general performance of the mechanically stabilized shoulders along the New York State Thruway by the Thruway Authority and the Bureau of Soil Mechanics of the Department of Public Works. The results of previous work by the Bureau were presented in a report, "New York State Thruway, New York City to Schenectady, Investigation of Performance of Shoulders", dated November 1956.

The following report concerns only that section of the Thruway between R.P. 145 and R.P. 146. The purposes of this particular report are as follows:

(A) To investigate and describe in detail by laboratory tests, the materials constituting the existing southbound outside shoulders between the above mileposts.

(B) To present recommendations describing the requirements for optimum shoulder materials.

(C) To present recommendations describing basic shoulder maintenance considerations and procedures.

(D) Using the data in (A), (B) and (C), to arrange, if feasible, a cost section and a control section between the above mileposts, and maintaining accurate cost records on these sections in order to indicate:

(a) Suitable and economical methods and procedures for maintaining properly constructed shoulders.

(b) The cost of maintaining properly constructed shoulders to achieve the desired performance requirements.

II. AUTHORIZATION

The cooperation and assistance of the Bureau of Soil Mechanics in this investigation were requested by C. H. Lang, Chief Engineer, New York State Thruway Authority, in a letter to T. F. FitzGerald, Chief Engineer, New York State Department of Public Works, dated July 12, 1957. Authorization and permission for the Bureau of Soil Mechanics to participate in this investigation were granted by Mr. FitzGerald.

III. ACKNOWLEDGMENT

This investigation was performed under the supervision and direction of Mr. Sidney Mintzer, Senior Soils Engineer of this Bureau, in cooperation with Mr. John Pendleton of the Thruway Authority. The field sampling operations were performed by personnel of the Bureau under the direction of Kenneth L. Reitmeier, Assistant Soils Engineer.

IV. SAMPLING PROCEDURE

The field sampling phase of the program was begun on August 15, 1957, and completed on August 19, 1957. The Thruway Authority supplied laborers, trucks, sampling tools and the necessary safety precautions.

The field sampling program consisted of removing representative materials from test pits dug at right angles to the pavement at intervals of 0.1 of a mile. The test pits were approximately

(b) The need of maintaining properly constructed shoulders to achieve the desired performance requirements.

II. AUTHORIZATION

The cooperation and assistance of the Bureau of Soil Mechanics in this investigation were requested by C. S. Lang, Chief Engineer, New York State Thruway Authority, in a letter to J. T. FitzGerald, Chief Engineer, New York State Department of Public Works, dated July 12, 1957. Authorization and permission for the Bureau of Soil Mechanics to participate in this investigation were granted by Mr. FitzGerald.

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This investigation was performed under the supervision and direction of Mr. Sidney Winiser, Senior Soils Engineer of this Bureau, in cooperation with Mr. John Mendleton of the Thruway Authority. The field sampling operations were performed by personnel of the Bureau under the direction of Kenneth L. Saltzmier, Assistant Soils Engineer.

IV. SAMPLING PROGRAM

The field sampling phase of the program was begun on August 15, 1957, and completed on August 19, 1957. The Thruway Authority supplied laborers, trucks, sampling tools and the necessary safety precautions.

The field sampling program consisted of removing representative materials from test pits dug at right angles to the pavement at intervals of 0.1 of a mile. The test pits were approximately

one foot wide, six feet long, with an average depth of four inches. The material was removed from the test pit, laid on a tarpaulin, thoroughly mixed and then a minimum of 50 pounds was bagged to comprise the representative sample for laboratory testing purposes. Due to the constant replacing of material along the edge of the pavement by maintenance operations, the test holes were not excavated closer than one foot from the edge of the pavement in order to indicate the characteristics of the bulk of the material comprising the shoulders. However, at intervals of approximately 0.2 of a mile, separate samples were taken immediately adjacent to the pavement edge to indicate the characteristics of the material currently being used to maintain the shoulders.

Forty-six locations were tested in which samples were taken not closer than one foot from the edge of the pavement. At 23 of these locations, separate samples were taken of the material lying adjacent to the pavement, making a total of 69 samples recovered for laboratory purposes.

V. SUMMARY OF LABORATORY TEST RESULTS

Table I "Summary of Laboratory Test Results" shows results of the laboratory classification tests performed on each of the 69 samples. Samples designated as "A" after the laboratory numbers were samples extracted immediately adjacent to the pavement edge. The results of the laboratory tests show that:

(1) Sixty-seven of the 69 samples tested contained percentages of material passing the 1/4 inch sieve considerably exceeding 65 percent. The average of the percentages passing the 1/4 inch sieve was 83.3.

(2) Many of the samples contained material larger than 2-1/2 inches. The average of the percentages of all samples exceeding 2-1/2 inches was 2.9.

(3) The average of the percentages passing the No. 200 sieve was 14.7.

(4) The average of the plasticity indices of the samples was 1.7.

(5) The soundness of the coarse fractions of the materials, as indicated by the magnesium sulfate test, was good. The average of the percent losses from the soundness test was 5.3.

VI. ANALYSES OF LABORATORY TEST RESULTS

The specifications for Item 2596, "Calcium Chloride Treated Gravel Shoulders", under which these shoulders were constructed require that 100 percent shall pass the 2-1/2 inch sieve; not more than 65 percent shall pass the 1/4 inch sieve; and not less than 10 percent nor more than 20 percent shall pass the No. 200 sieve.

It is obvious from V(1) and V(2) that the shoulders investigated in this section contain a considerable proportion of material exceeding 2-1/2 inches in size and far too high a percentage of material passing the 1/4 inch sieve to conform to the requirements for Item 2596. This condition is illustrated in Fig. 1.

Either the material installed during the original construction of these shoulders did not conform to Item 2596, or material added during subsequent maintenance adversely altered the grain size characteristics of the original material.

Gravel exceeding 2-1/2 inches in size does not adversely affect the stability of the shoulder, but it does cause maintenance difficulties because the cobbles are continuously being plucked out during the necessary manipulation required by proper maintenance.

However, too high a percentage of the material passing the 1/4 inch sieve does adversely affect the stability, particularly during the spring thaws. Also, too high a percentage of such sizes contributes to shoving, dusting and whipping during dry weather.

It is the opinion of this Bureau that the percentage of the minus No. 200 size in any mechanically stabilized shoulder material should vary between 10 and 20 percent. V(3) above, indicates that the existing shoulder material conforms to this opinion, and conforms to the requirements of Item 259C in this respect. This percentage range is generally suitable for mechanically stabilized mixtures only.

It is also the opinion of this Bureau that mechanical stabilized shoulder materials should possess some reasonable plasticity index, preferably not less than 3, but not greater than 6. This P.I. range is generally suitable for mechanically stabilized mixtures only.

VII. RECOMMENDATIONS, CONSTRUCTION AND RECONSTRUCTION

This Bureau offers the following recommendations concerning the requirements governing mechanically stabilized shoulder materials to be used in construction and reconstruction of shoulders:

(1) Gradation: The material should be well graded from coarse to fine and conform to the following:

Size	Percent Passing by Weight
2-1/2 inch sieve	100
1/4 inch sieve	30 to 65
No. 200 sieve	10 to 20

(2) Soundness: The percent loss of the coarser fraction (+1/4 inch) after four cycles of the magnesium sulfate test should not exceed 30. This maximum loss should be considered tentative, since research is presently being performed by this Bureau in order to establish a rational limit for shoulder materials in this respect. In the interim, 30 percent is considered a reasonable limit.

(3) Plasticity: The fraction passing the No. 40 sieve should have a liquid limit not exceeding 25, and a plasticity index not greater than 6. (As indicated in V(1) above, some plasticity of the fines is desirable and, if possible, materials having P.I.'s approximating 3 should be used.)

(4) The percentage passing the No. 200 sieve shall not be greater than two-thirds of the percentage passing the No. 40 sieve.

The above recommended requirements are an expansion of the requirements of Item 59C, "Stabilized Gravel Surface Course, Calcium Chloride Treatment", Public Works Specifications of January 2, 1957.

The above requirements may be modified to utilize local materials, provided that the results of adequate laboratory tests and/or

past performance indicate that such materials are suitable. This particularly applies to the use of stone screenings, where experience indicates that stone screenings from some sources are suitable for the construction of adequate shoulders.

To obtain satisfactory shoulder performance, it is essential that the shoulders be provided with thoroughly compacted, well drained subgrades composed of suitable materials. Shoulders require adequate subgrade support in order to satisfactorily sustain occasional heavy wheel loads during all seasons of the year; however, stable shoulder subgrades are particularly necessary during the spring thaws.

VIII. RECOMMENDATIONS, MAINTENANCE

The performance of shoulders depends, not only upon the characteristics of the materials constituting the shoulders and the subgrade foundations thereof, but upon the frequency and quality of maintenance provided. Shoulders may be constructed of materials possessing optimum characteristics, but if inadequate maintenance is performed, the shoulders will, in general, revert to an unsatisfactory condition. On the other hand, it is also quite possible that shoulders, composed of materials reasonably deviating in characteristics from the optimum standards, will show adequate performance if adequate maintenance is provided. The latter type of shoulders obviously requires a somewhat higher degree of maintenance than do those composed of materials conforming to optimum standards. The importance of proper maintenance procedures on shoulder performance cannot be over-emphasized.

The time, frequency and type of shoulder maintenance operations greatly influence shoulder performance. This Bureau

recommends the following basic considerations as being extremely important and necessary in the proper maintenance of shoulders to result in satisfactory performance:

(1) Shoulders should be manipulated, bladed and rolled only when the moisture content of the material is at or slightly above the optimum necessary for proper compaction and maximum density. The optimum moisture and manipulation conditions usually occur, naturally, during the spring and fall. Major shoulder maintenance operations should, therefore, be performed during these seasons. During prolonged dry periods, such as in the summer, it is usually necessary to add water to achieve adequate density of the shoulder material.

(2) If it becomes necessary to add material to a shoulder, the material added should be of suitable gradation and quality so as to beneficiate the characteristics of the existing shoulder material, if such does not possess the optimum characteristics. If the existing shoulder material is of the optimum gradation and quality, any material added should maintain those optimum characteristics in the resulting mixture. The application of additional material to a shoulder should always result in either approaching or maintaining the optimum requirements for shoulder materials, as recommended in VII above.

(3) The practice of adding a relatively thin layer of new material to the relatively dry, compact surface

of a shoulder to eliminate the "drop-off" at the edge of the pavement, should be avoided. The layer of material added in this manner will usually not properly integrate or bind with the compact surface of the existing shoulder, regardless of whether calcium chloride is first applied, and, consequently, may soon be removed by the action of the various factors that caused the "drop-off" in the first place. If it becomes necessary to build up a shoulder, the existing compact shoulder surface upon which the additional material is to be placed should first be scarified and loosened, so that the additional material and calcium chloride can be incorporated into the shoulder to provide an integral course.

(4) Shoulders should be compacted with a suitable and adequate roller after manipulation and blading, particularly after incorporation of additional material. Thorough rolling is very important and necessary, since the occasional traffic which a shoulder receives cannot be depended upon to achieve required densities; <u>thorough rolling is necessary</u>.

(5) As stated in (1) above, both the material added to the shoulder, as well as the scarified or loosened layer, must be at the optimum moisture content immediately prior to compaction by rolling, if the necessary density is to be attained. To achieve this optimum condition of moisture, it may be necessary to add water, or calcium chloride in solution form.

Suitable moisture conditions may be preserved in shoulder material stockpiles by incorporating the calcium chloride in flake form during the formation of the stockpiles.

(6) For the purpose of structural stabilization of the shoulder course, calcium chloride should be incorporated into the material when it is in a loose or scarified condition. The stabilization effect of placing calcium chloride, either in flake or solution form, on an impermeable compact shoulder surface is generally limited, and this treatment should, therefore, be considered for dust and surface moisture control purposes only.

(7) Calcium chloride in flake form is only effective when there is sufficient moisture in the soil or air to satisfy its hygroscopic and deliquescent actions. These actions are severely retarded when applications are made to dry soils in hot, dry periods of prolonged drought. Surface applications, in flake form during such periods, are generally ineffective since the chemical cannot pick up sufficient moisture from the air before the flakes are whipped away. Surface applications during dry periods should be done in solution form, or the surface should be thoroughly moistened before application in flake form.

It is obvious, after a consideration of the above factors, that the most desirable times for major shoulder maintenance operations are in the spring and fall of the year when the material is naturally close to its optimum moisture content for efficient blading and compaction.

IX. SUGGESTED TEST SECTIONS

In order to properly evaluate the performance of mechanically stabilized shoulders, it is important to know the average annual cost required to adequately maintain a unit length of properly constructed shoulder. Such information is essential in any overall economic comparison between the first costs and annual maintenance costs of mechanically stabilized shoulders and any other types of shoulders. The average annual unit maintenance cost can be determined with reasonable accuracy by keeping a complete record of the cost required to adequately maintain a shoulder test section composed of suitable materials. Such a test section can be arranged by reconstructing a section of reasonable length to conform to requirements of a suitable shoulder material, or choosing a section where the existing materials are considered to be in conformance with suitable shoulder material requirements. The existing shoulders of some portions of the Thruway are composed of suitable materials. Preliminary investigations by this Bureau indicate that the southbound shoulder of the section between Kingston and Whiteport is composed of materials conforming with near optimum requirements. (See "New York State Thruway, Investigation of Performance of Shoulders", November 1956)

Control sections of reasonable lengths should also be arranged on shoulders composed of materials representing the average Thruway shoulder condition, in order to determine the difference in cost, if any, necessary to properly maintain shoulders composed of optimum and average materials.

The Bureau of Soil Mechanics would be very interested in cooperating with the Thruway Authority in such a program.

X. CONCLUSIONS

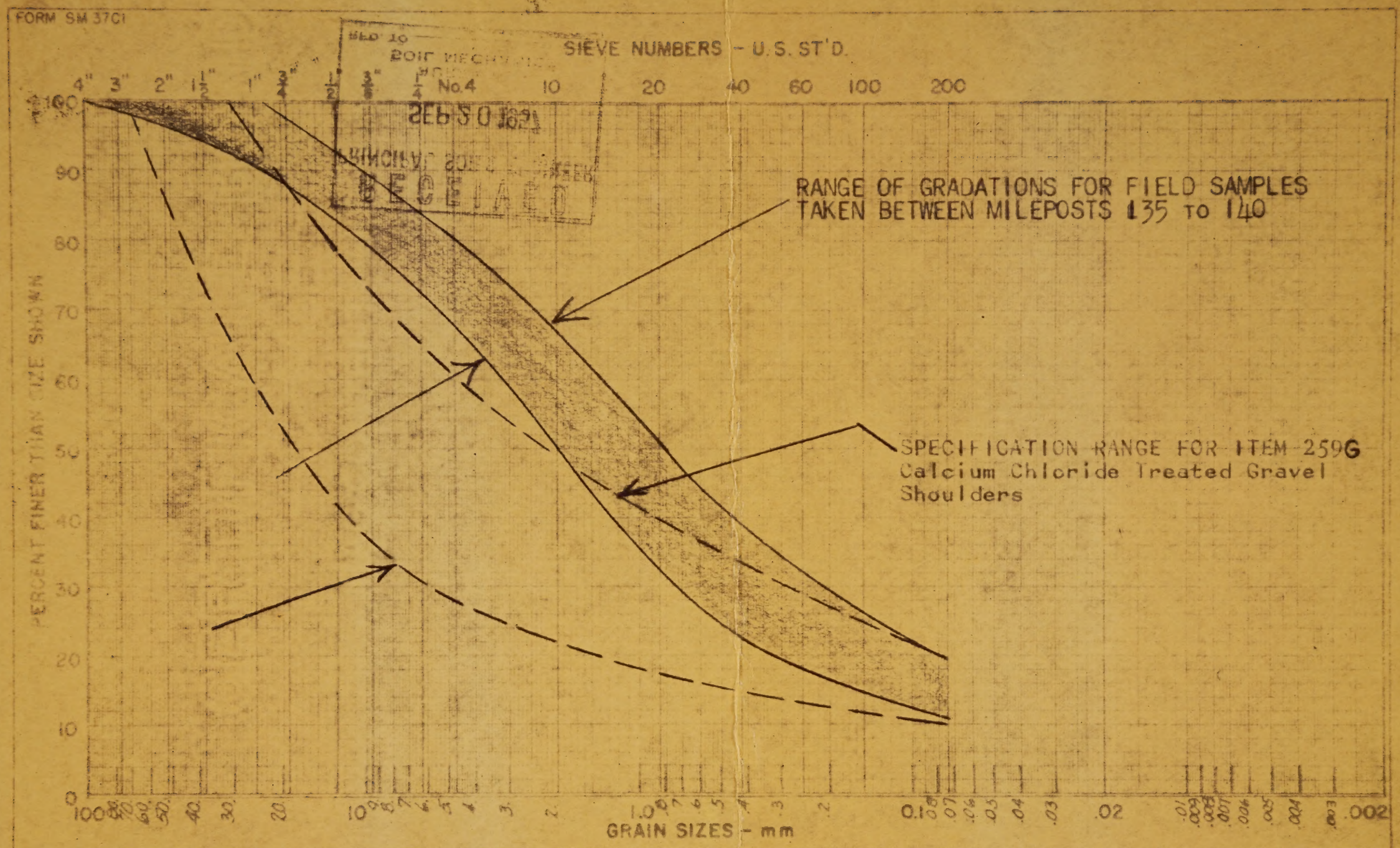
(1) The materials composing the existing southbound outside shoulder between M.P. 135 and 140 do not conform to Item 259G, containing:
   (a) Material exceeding 2-1/2 inches in size.
   (b) Excessive percentages of minus 1/4 inch size.

(2) The requirements and characteristics of an optimum material for mechanically stabilized shoulders are recommended in VII above.

(3) Basic and important shoulder maintenance considerations, procedures and methods necessary for satisfactory mechanically stabilized shoulder performance are recommended in VIII above.

Wm. P. Hofmann
Principal Soils Engineer

FORM SM 3701



PROJECT NEW YORK STATE THRUWAY SHOULDER INVESTIGATION-AUGUST 1957

SAMPLE NO _____ DISTRICT NO 1 COUNTY ALBANY

STATION _____ OFFSET 18 INCHES FROM EDGE OF PAVEMENT DEPTH 0 TO 4 INCHES

DATE SEPT. 18, 1957 DRAWN BY S. MINTZER

STATE OF NEW YORK
DEPARTMENT OF PUBLIC WORKS
DIVISION OF CONSTRUCTION
BUREAU OF SOIL MECHANICS
GRAIN SIZE DISTRIBUTION CURVE

FIGURE 1

September 23, 1957
Table I

STATE OF NEW YORK - DEPARTMENT OF PUBLIC WORKS
BUREAU OF SOIL MECHANICS

NEW YORK STATE THRUWAY SHOULDER PROJECT

SUMMARY OF LABORATORY TEST RESULTS
MILEPOSTS 135 TO 140
AUGUST, 1957

SOUTHBOUND OUTSIDE SHOULDER ONLY

Mileage Location	Laboratory Number	Percent Finer Than Sieve 2-1/2"	2"	1"	1/4"	#4	#10	#40	#60	#100	#200	0.02MM	% +2-1/2"	% 200/40	L.L. %	P.I.	% Loss Mg SO4
36' So. M.P. 140	1	100.0	99.3	96.5	83.2	79.2	60.[illegible]	19.4	15.3	13.1	10.8	4.6	7.5	55.7	19.0	0.6	--
	1A		100.0	92.6	75.9	74.0	[illegible]	27.3	20.2	16.2	13.4	7.5	0	49.1	19.3	2.8	--
60' So. of 4th Marker So. of MP.140	2	100.0	99.0	93.7	83.1	80.2	64.1	22.0	17.3	14.7	12.5	5.9	0	56.8	19.0	2.3	7.7
53' So. of 8th Marker So. of MP.140	3	100.0	98.8	93.1	78.3	74.6	60.5	30.4	27.5	24.5	17.1	6.2	0	56.1	17.7	0.9	4.3
	3A	100.0	95.3	90.0	73.3	69.3	58.6	29.8	26.3	23.2	15.8	5.4	0	53.0	15.9	0.5	--
39' So. of 12th Marker So. of MP140	4	100.0	99.5	95.4	82.2	77.0	59.4	24.1	20.6	18.3	15.6	6.4	6.7	64.7	20.4	5.6	--
62' So. of 16th Marker So. of MP140	5	100.0	99.1	96.5	85.7	81.1	63.2	24.6	19.4	16.8	13.9	6.3	1.4	56.5	--	NP	--
	5A		100.0	95.2	81.8	77.5	57.5	20.9	17.2	14.6	11.3	5.0	0	54.1	17.9	0.3	--
58' So. of 20th Marker So. of MP 140	6	100.0	99.0	93.2	80.1	74.6	52.0	19.5	16.7	14.8	12.4	5.3	6.4	63.6	18.9	1.6	4.2
74' So. of 30th Marker So. of MP 140	7	100.0	95.4	89.6	75.9	70.9	51.7	23.3	20.3	18.1	14.9	7.2	14.1	63.9	18.7	3.7	5.9
	7A		100.0	97.9	82.6	78.4	58.4	24.1	20.1	17.2	13.3	5.9	0	55.4	16.4	0.8	--
34' So. of 34th Marker So. of MP.140	8	100.0	97.6	93.6	82.7	78.5	62.4	33.4	30.1	25.7	15.5	5.6	8.2	46.3	--	NP	--
30' So. of 2nd Marker So. of MP. 139	9		100.0	96.2	86.6	84.1	70.9	45.1	41.5	35.2	17.0	3.5	0	37.6	--	NP	--
	9A		100.0	97.4	87.8	86.5	74.6	43.5	39.4	31.5	12.0	5.1	0	27.7	--	NP	--
63' So. of 6th Marker So. of MP. 139	10		100.0	97.7	92.5	90.0	73.6	28.1	21.4	18.6	14.1	6.4	0	50.0	17.9	1.8	--
55' So. of 10th Marker So. of MP. 139	11		100.0	97.8	87.0	82.9	63.4	28.4	24.2	20.8	16.0	6.8	0	56.4	18.6	3.6	--
	11A		100.0	94.9	83.0	78.9	61.6	25.0	20.4	17.4	13.7	6.8	0	54.7	18.9	3.0	--
44' So. of 14th Marker So. of MP. 139	12		100.0	96.7	84.5	79.4	60.9	32.5	28.2	24.7	13.8	4.8	7.6	42.5	--	NP	--
61' So. of 18th Marker So. of MP.139	13	100.0	99.0	97.1	90.9	85.0	65.6	23.7	19.5	16.4	12.3	4.7	3.7	51.7	16.5	1.4	--
	13A			100.0	93.3	91.0	76.6	33.8	27.9	22.7	15.5	6.3	0	45.7	--	NP	--
35' So. of 22nd Marker So. of MP. 139	14	100.0	98.0	95.1	86.9	83.5	64.0	26.2	22.2	18.6	13.8	5.2	15.2	52.7	17.6	1.4	--
55' So. of 26th Marker So. of MP. 139	15		100.0	91.9	84.2	80.3	63.1	25.3	21.0	17.8	14.0	6.2	1.8	55.4	17.9	1.3	--
	15A		100.0	99.4	92.0	88.7	72.9	29.0	22.5	18.7	14.7	8.0	0	50.7	17.6	1.3	--
49' So. of 30th Marker So. of MP. 139	16	100.0	98.1	96.5	90.2	87.3	69.9	31.6	26.5	22.1	16.5	7.1	0	52.3	--	--	--
43' So. of MP. 138	17	100.0	98.0	93.8	73.5	69.0	52.5	28.9	25.4	22.4	17.9	6.7	4.6	61.3	--	--	--
	17A	100.0	96.8	88.1	64.9	59.1	45.6	22.5	19.1	16.7	14.2		0	62.9	20.6	4.8	--
52' So. of 4th Marker So. of MP 138	18		100.0	91.8	80.8	76.5	58.5	24.9	21.6	18.7	14.3	5.8	0	57.5	17.9	1.9	--
45' So. of 8th Marker So. of MP 138	19	100.0	98.0	92.3	80.1	75.5	57.7	26.2	22.7	19.5	14.9	5.6	9.2	56.9	--	--	--
	19A		100.0	89.4	54.1	50.2	38.6	20.1	17.6	14.9	11.1	4.6	0	55.0	--	--	--
71' So. of 12th Marker So. of MP. 138	20		100.0	93.0	83.8	80.9	66.4	33.6	29.1	21.2	12.7	5.5	6.5	37.6	--	--	4.7
62' So. of 16th Marker So. of MP. 138	21	100.0	97.6	94.2	83.0	78.9	60.4	26.2	22.6	18.8	13.0	5.6	0	49.6	--	--	5.4
	21A		100.0	97.0	88.6	84.0	65.4	33.4	29.2	23.8	15.1	5.3	0	45.0	--	--	--
34' So. of 20th Markder So. of MP. 138	22	100.0	97.7	92.9	81.1	77.7	63.0	31.3	27.3	22.8	15.3	5.9	5.8	48.7	16.2	0.2	6.2
71' So. of 24th Marker So. of MP. 138	23	100.0	99.0	93.3	82.1	78.1	62.9	31.7	26.2	20.9	13.4	4.6	1.7	42.1	--	--	6.0
	23A		100.0	92.8	82.0	78.5	64.5	34.2	28.8	22.7	13.7	5.7	0	40.0	--	--	--
55' So. of 28th Marker So. of MP. 138	24	100.0	97.9	95.2	85.0	82.1	70.0	35.2	28.4	23.8	16.8	5.7	2.9	47.7	--	--	7.8
39' So. of 32nd Marker So. of MP. 138	25		100.0	98.4	88.3	84.8	68.4	36.7	32.3	26.7	16.3	5.7	15.2	44.4	--	--	--
	25A		100.0	98.4	86.6	81.6	63.0	29.7	25.4	21.6	15.4	6.3	0	51.8	--	--	--
56' So. of 36th Marker So. of MP. 138	26	100.0	98.2	93.8	82.3	78.3	63.3	29.8	23.4	19.6	14.2	5.9	15.4	47.7	--	--	--
54' So. of MP. 137	27		100.0	96.1	85.1	82.3	64.7	34.9	31.1	24.7	14.9	4.9	4.3	42.6	--	--	--
	27A		100.0	94.9	80.4	76.0	62.7	38.6	34.2	27.5	17.9	6.4	0	46.3	--	--	--
53' So. of 4th Marker So. of MP. 137	28	100.0	98.3	95.3	86.4	82.0	67.0	31.9	25.8	21.1	15.2	5.5	0	47.6	16.2	2.3	--
79' So. of 8th Marker So. of MP. 137	29	100.0	96.4	93.2	83.3	79.4	68.0	41.0	36.7	28.5	16.5	4.3	3.9	40.2	--	--	--
	29A		100.0	94.5	84.4	81.6	65.5	34.3	29.8	24.0	15.0	5.6	0	43.6	--	--	--
85' So. of 12th Marker So. of MP. 137	30	100.0	97.3	89.6	78.9	75.3	61.4	30.5	24.8	20.9	16.3	7.3	0	53.6	--	--	--
45' So. of 16th Marker So. of MP. 137	31	100.0	98.3	88.6	76.8	72.5	56.5	28.4	24.4	20.0	13.8	5.7	5.3	48.4	--	NP	--
	31A		100.0	96.2	84.6	76.7	53.4	23.7	20.6	17.5	12.9	5.7	0	54.6	17.1	0.6	--
65' So. of 20th Marker So. of MP. 137	32	100.0	97.7	91.8	76.8	72.1	55.5	33.4	26.7	23.4	14.8	5.1	15.6	44.5	--	--	--
64' So. of 24th Marker So. of MP. 137	33		100.0	94.5	82.3	78.0	62.4	34.4	29.3	21.8	18.8	7.5	0	54.5	--	--	--
	33A		100.0	97.2	86.0	78.5	55.4	27.7	24.9	22.0	17.9	6.4	0	64.6	16.9	1.5	--
45' So. of 30th Marker So. of MP. 137	34		100.0	94.2	80.6	75.1	57.4	29.0	25.3	20.7	14.6	5.9	2.3	50.4	--	--	--
30' So. of 34' Marker So. of MP. 137	35	100.0	98.8	96.0	85.5	79.3	54.3	20.2	16.0	12.8	9.8	3.7	10.6	48.3	--	NP	--
	35A		100.0	94.9	73.1	68.9	52.1	19.1	15.1	12.1	9.3	4.0	0	48.6	18.3	1.5	--
48' So. of MP. 136	36	100.0	98.6	94.6	85.4	81.9	65.9	26.4	20.8	17.8	15.5	6.2	13.7	58.6	--	--	6.6
58' So. of 4th Marker So. of MP. 136	37	100.0	99.7	96.1	85.9	81.4	64.5	29.4	22.1	18.4	15.5	6.1	1.4	52.6	--	--	--
	37A		100.0	98.2	88.8	87.6	73.9	33.6	25.3	20.2	15.8	7.6	0	47.1	18.1	1.8	--
50' So. of 8th Marker So. of MP. 136	38		100.0	95.0	85.4	81.0	63.8	26.2	20.6	17.3	14.7	6.6	0	56.3	18.8	2.2	--
15' So. of 12th Marker So. of MP. 136	39	100.0	98.5	93.3	84.8	79.1	61.3	22.6	17.4	14.5	12.3	5.1	1.4	54.4	--	--	--
	39A		100.0	96.7	87.9	83.8	66.9	26.8	20.2	16.7	14.1	6.3	0	52.5	17.4	1.0	--
43' So. of 16th Marker So. of MP. 136	40	100.0	98.1	93.7	82.8	77.6	60.6	24.2	17.6	14.1	11.3	4.8	0	46.9	--	--	4.1
61' So. of 20th Marker So. of MP. 136	41		100.0	90.1	78.7	74.1	58.5	22.5	17.6	15.1	12.8	5.6	3.4	57.0	18.7	1.8	4.1
	41A		100.0	98.1	86.0	80.9	65.4	29.1	23.0	19.2	15.7	6.8	0	53.8	--	--	--
36' So. of 24th Marker So. of MP.136	42		100.0	96.7	86.1	82.5	69.5	43.5	37.6	32.2	25.2	10.6	0	57.8	--	--	--
78' So. of 28th Marker So. of MP.136	43		100.0	96.0	84.5	82.4	66.6	27.0	22.0	18.7	15.0	7.0	0	55.4	--	--	2.1
	43A		100.0	99.7	89.1	84.3	66.9	27.8	22.1	18.6	15.2	6.5	0	54.6	--	--	--
61' So. of 32nd Marker So. of MP.136	44		100.0	97.1	88.5	84.0	68.0	26.9	19.3	16.1	13.6	6.1	0	50.3	--	--	--
59' So. of 36th Marker So. of MP.136	45		100.0	95.8	87.2	82.8	65.9	30.8	25.2	21.4	17.7	7.2	0	57.4	28.1	10.5	4.7
	45A		100.0	99.6	93.4	89.1	72.8	36.9	30.4	25.2	19.4	7.7	0	52.6	17.2	0.9	--
52' So. of MP 135	46		100.0	98.8	90.2	86.5	75.0	34.1	24.4	20.2	16.8	7.2	3.9	49.4	--	--	--
Average		100.0	99.2	94.9	83.3	79.2	62.8	29.1	24.3	20.3	14.7	6.0	2.9	51.4	18.3	1.7	5.3
Callanan Washed Screenings					100.0	99.9	68.8	18.2	10.4	6.1	3.9	1.5	0	21.4	--	NP	--
Callanan Unwashed Screenings				100.0	99.7	99.3	84.5	29.7	22.8	19.1	16.4	8.7	0	55.1	--	NP	--
Gillespie Pit Gravel (Average 7 Samples)		100.0	98.4	94.2	68.8	61.4	35.5	11.1	7.7	6.2	5.4	1.7	1.5	48.7	18.4	1.1	14.2
Gillespie Pit Overburden			100.0	92.8	60.8	56.3	42.0	29.0	26.7	25.2	23.5	10.8	0	81.0	23.4	5.7	--

REMARKS: The samples designated as "A" were all taken at 0" - 17" from edge of pavement.

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